Research on Design Features in Senior Brassiere through Body Factor Analysis

Dr. Newman Lau

PolyU UoA 38

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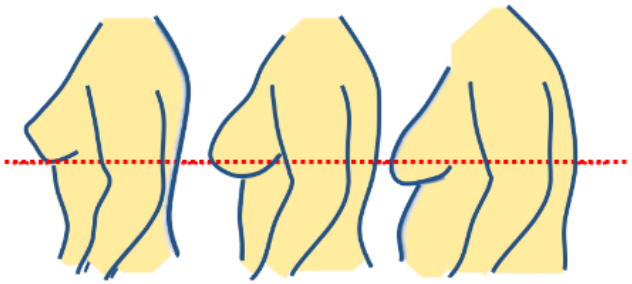
Descriptor

What are the design features of brassieres for sagging breasts of senior women?

Nowadays, many senior women do sports, e.g., yoga, to improve their body health, however, they tend to be troubled by sagging breasts and difficulties to turn their arms and fasten the bra. Sports brassieres are designed mainly for young women. The current sports brassiere design in the market may not be suitable for senior women both causal social activities or sports, in such the aesthetic perception, functional requirement, human factor features are not well considered through design and numerical analysis.

This research investigated the human factor design on senior brassiere using various design analysis and combine the numerical analysis and simulation to enhance the research in the area of deriving design features and framework for senior women clothing and sports wear. The research method conducted include human factor design analysis, breast shape feature analysis, motion capture and analysis on skin deformation, finite element analysis and simulation.

The originality of this research is the interdisciplinary collaboration with the domain of design research to textile and clothing, and also mechanical engineering approach in supporting the design features in relation to human body factors and comfort. From the analysis of user personas, physical and psychological needs, sports exercise behaviour, brassieres design and comfort issues, and also with the reference from experiments, wear trial results, design criteria with features of construction were established. The idea of this was to ensure the brassiere that meet the design needs, has effective support, high stability and comfort in a way that is also easy to wear.



Biography

Dr. Newman Lau
Associate Professor
School of Design
The Hong Kong Polytechnic University

Dr. Newman Lau is the Associate Professor in the School of Design. He specializes in user experience design and applies the concepts to cross-disciplinary works. His current research focuses on human factor design through user behavior, motivation, and user-centric analysis. Design for healthcare and wellbeing is one of his major project themes. Capturing and analyzing human body movement is his core research topics. Various research projects include interpreting movement appears in various areas, for instance, ergonomics, sports, wearables in daily activities, etc. Based on his extensive network with the industry and society, collaboration with various stakeholders has been facilitated in various research publications, funded research projects and awards. That aligns entities ranging from design, engineering, healthcare, community, business, etc.

He has more than 40 research publications, in which about 10 of those are journal articles, including International Education Studies, International Journal of Visual Design, Leonardo, Journal of Biomechanics, Journal of Human Kinetics, Motor Control, Materials, Design Principles and Practices: An International Journal, etc., with the highest Impact Factor as 2.972 from InCites Journal Citation Reports.

Research Questions

The research sets out to:

1. Investigate the human factor design on senior brassiere using design analysis directly from senior women users both in HK and mainland, and structural analysis of existing brassieres in the market as primary findings.
2. Determine the non-linear properties of breast deformation during casual and sports activities.
3. Research method conducted include human factor design analysis, breast shape feature analysis, motion capture and analysis on skin deformation, and finite element pressure analysis and simulation.
4. Combine the numerical analysis and simulation to enhance the research in the area of deriving design features and framework for senior women clothing and sports wear.
5. Design the aged-friendly brassieres for aesthetic and functional design with features in construction and materials.

Research Questions

Keywords

1. Breast deformation
2. Age-friendly brassiere
3. Active wear design
4. Breast skin extension
5. Finite element modeling

Research Methods & Materials

Milestone 1: Investigate the human factor design on brassiere of senior women

- Task 1: Human factor design analysis directly from senior women users both in HK and mainland.
- Task 2: Structural analysis of existing brassieres in the market as primary findings.

Milestone 2: Determine the non-linear properties of breast deformation

- Task 1: Conduct research methods including breast shape feature analysis, motion capture and analysis on skin deformation during activities.
- Task 2: Combine the numerical analysis to quantify and visualize the research in non-linear properties of breast deformation.

Research Methods & Materials

Milestone 3: Derive evidences on design features of brassiere from analysis and simulation

- Task 1: Preparation of the geometric model - components of the finite element model includes the breast, body, sternocostal and clavicular portion, brassieres and individual subject body scanning model.
- Task 2: Apply gravity on breast with the movement simulation of arm rotation and displacement based on experimental data. Deformation of breast is simulated with pressure and stress distribution.

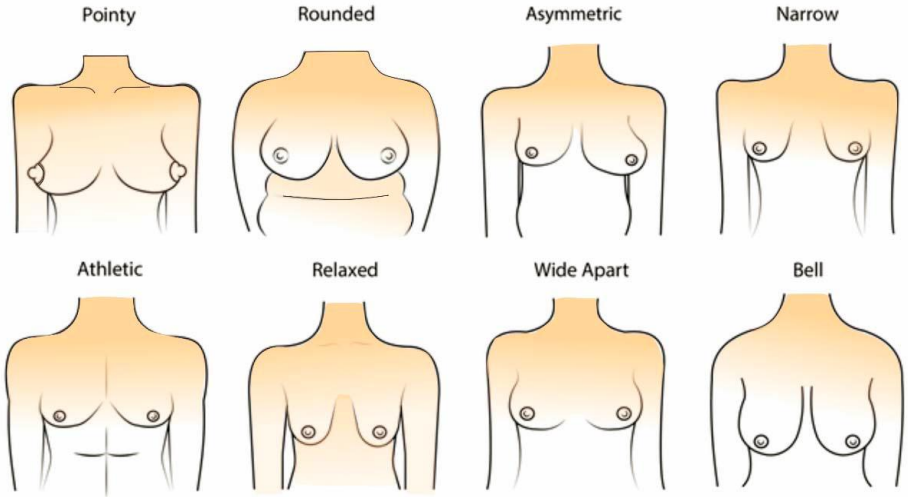
Milestone 4: Findings are suggested to design features of a collection of senior brassiere styles

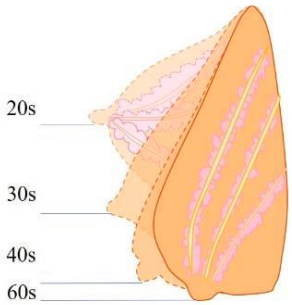
- Task 1: Design collection of 8 styles of aesthetic and functional brassieres for senior women

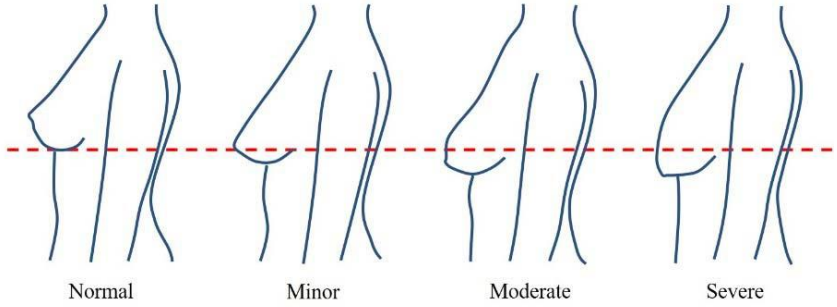
Research Methods & Materials

Milestone 1: Investigate the human factor design on brassiere of senior women

Task 1: Human factor design analysis directly from senior women users both in HK and mainland.



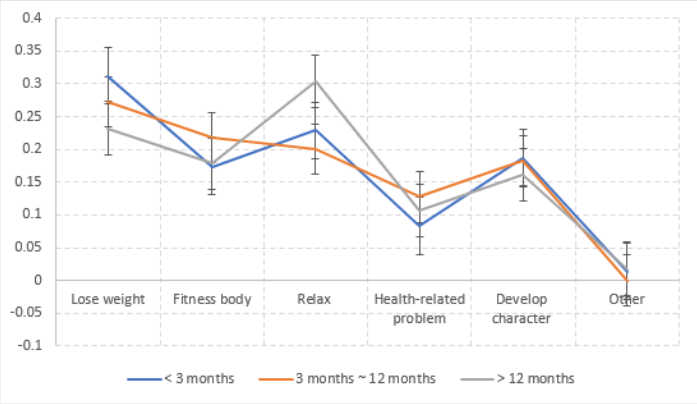




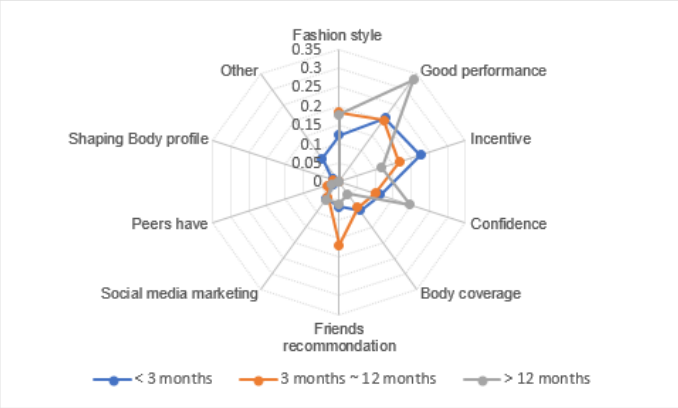
Research Methods & Materials

Milestone 1: Investigate the human factor design on brassiere of senior women

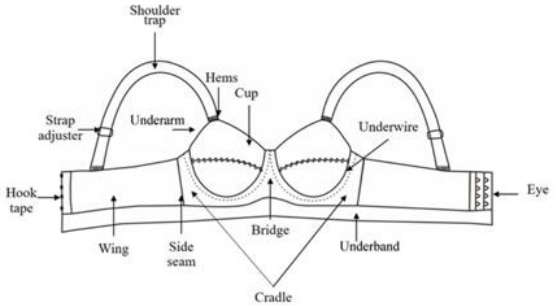
Task 2: Structural analysis of existing brassieres in the market as primary findings.



The reasons for participating in Yoga exercise.



The considered factors of wearing a sports bra for senior women with different yoga exercise history.



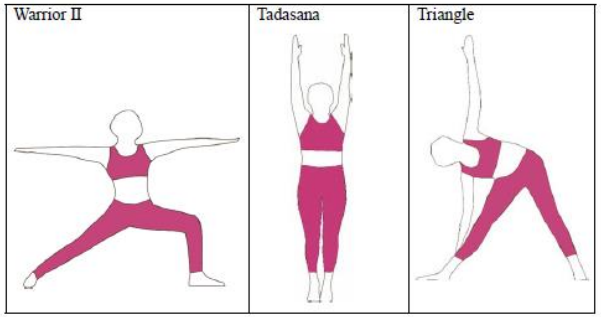
Main structural components of a typical sports/yoga bra

Component	Design criteria	Features
Fabric	Breathable Thermal comfort	- Natural jade cool fabric - Odor resistance polyester knitted fabric - Breathable and thin materials
Elastic strap	No spreading Easy to adjust Easy to wear Easy to move	- Adjustable straps and closure - Front adjusted strap - No digging - Strong elastics with good recovery
Neckline	No exposure	- Higher neckline
Back	Large movement space Hidden back fat	- Not cross-back and pull-over bra - Back design: Narrow panel
Armhole	Large movement space	- Concave panel
Underbust	Hidden the fat	- Wider underband
Cup	Round breast shape No sagging	- Molded tailor-made cup for elderly
Side panel	Lift up the breast	- Special cutting to lift up and firm the breast
Aesthetic	Fashionable Look younger	- Dark color or pastel color - Long shirt for cover the aging body - Color matching
Closure	Easy to wear Easy to move	- Front adjusted closure
Wing	Better coverage	- Wider wing design

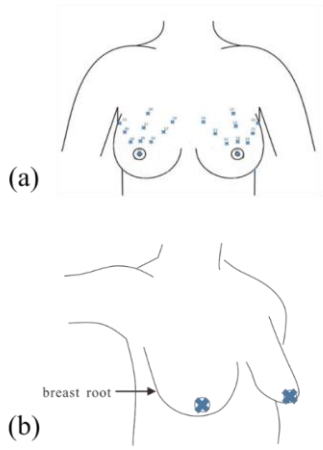
Research Methods & Materials

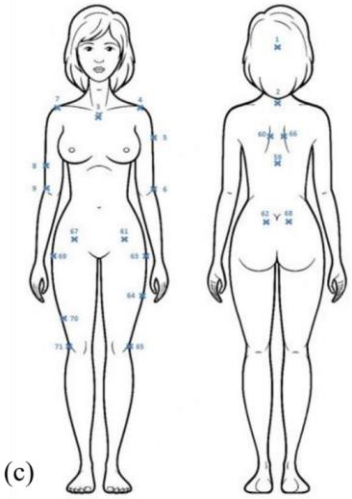
Milestone 2: Determine the non-linear properties of breast deformation

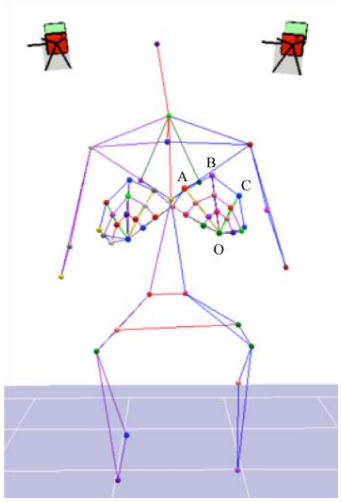
Task 1: Conduct research methods including breast shape feature analysis, motion capture and analysis on skin deformation during activities.



yoga poses for motion capture



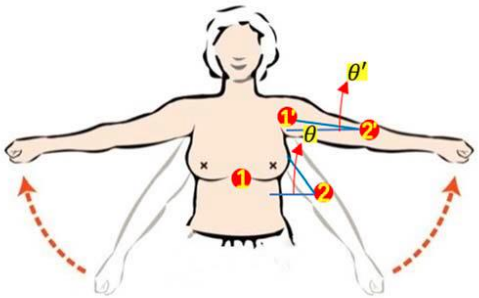


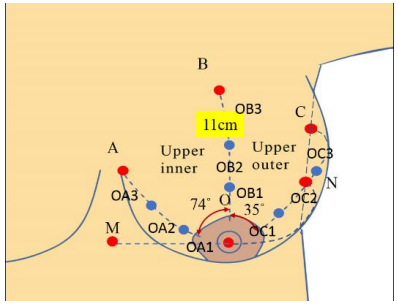


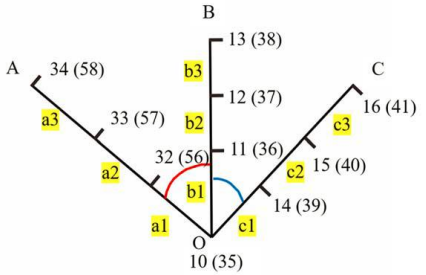
Research Methods & Materials

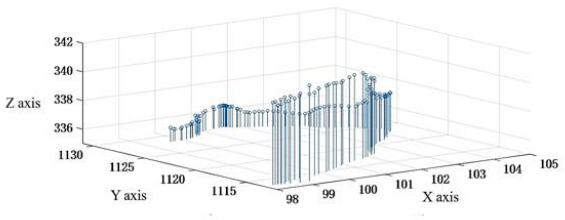
Milestone 2: Determine the non-linear properties of breast deformation

Task 2: Combine the numerical analysis to quantify and visualize the research in non-linear properties of breast deformation.

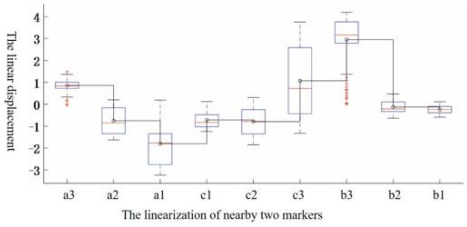




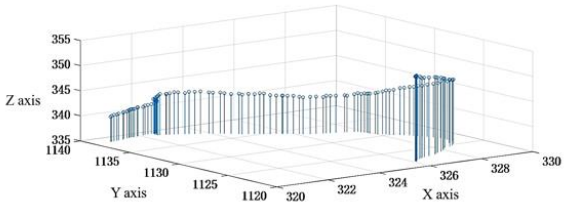




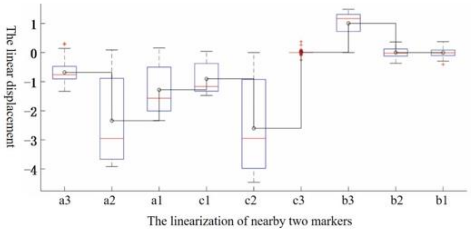
The left breast nipple trajectories during arm abduction



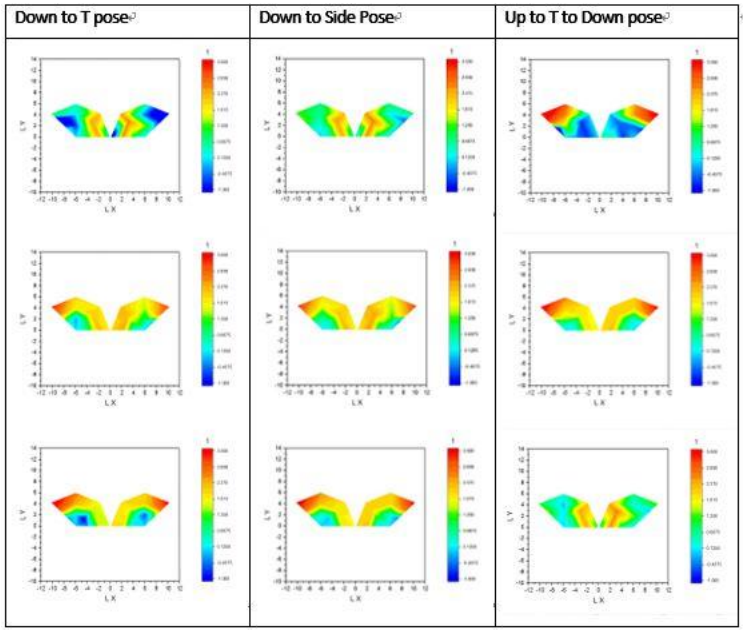
The box diagram of markers linear displacement on left breast



The right breast nipple trajectories during arm abduction



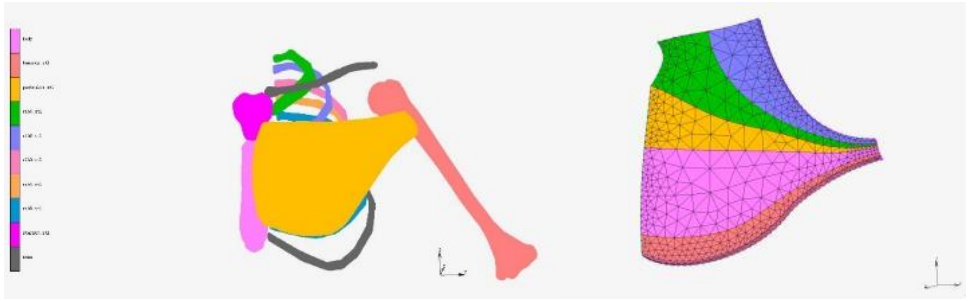
The box diagram of markers linear displacement on right breast

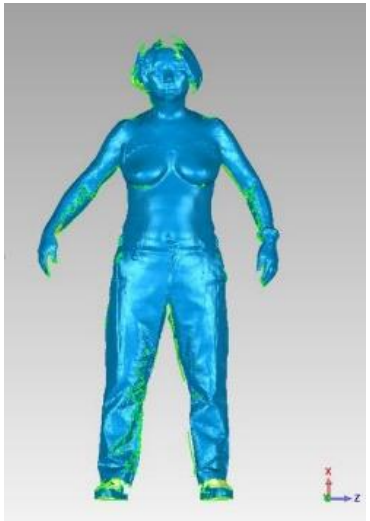


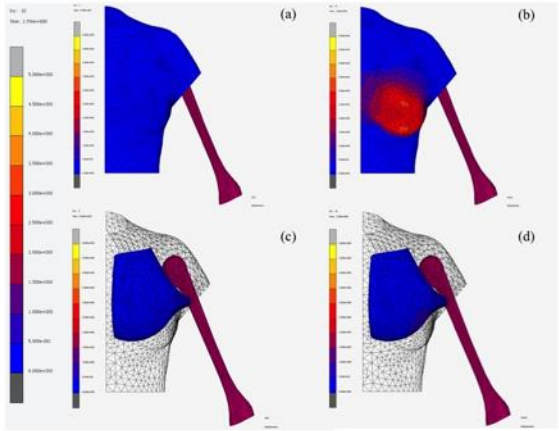
Research Methods & Materials

Milestone 3: Derive evidences on design features of brassiere from analysis and simulation

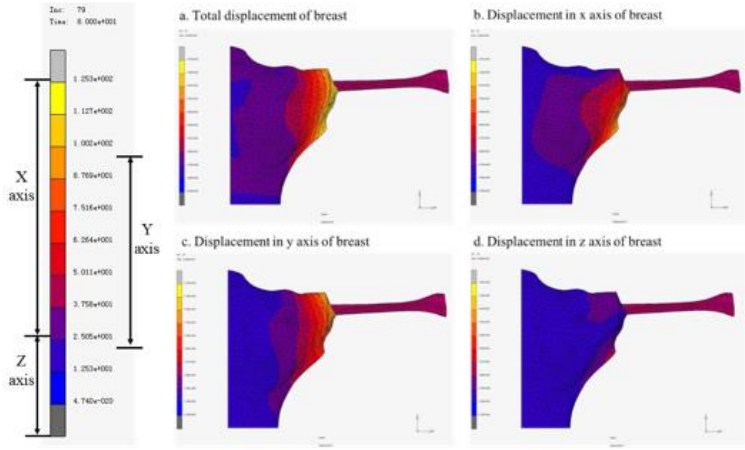
Task 1: Preparation of the geometric model - components of the finite element model includes the breast, body, sternocostal and clavicular portion, brassieres and individual subject body scanning model.



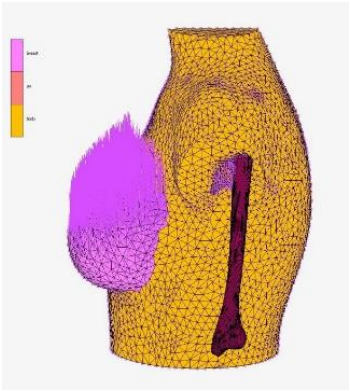




The comparison of the breast displacement and PMM displacement under different loading conditions



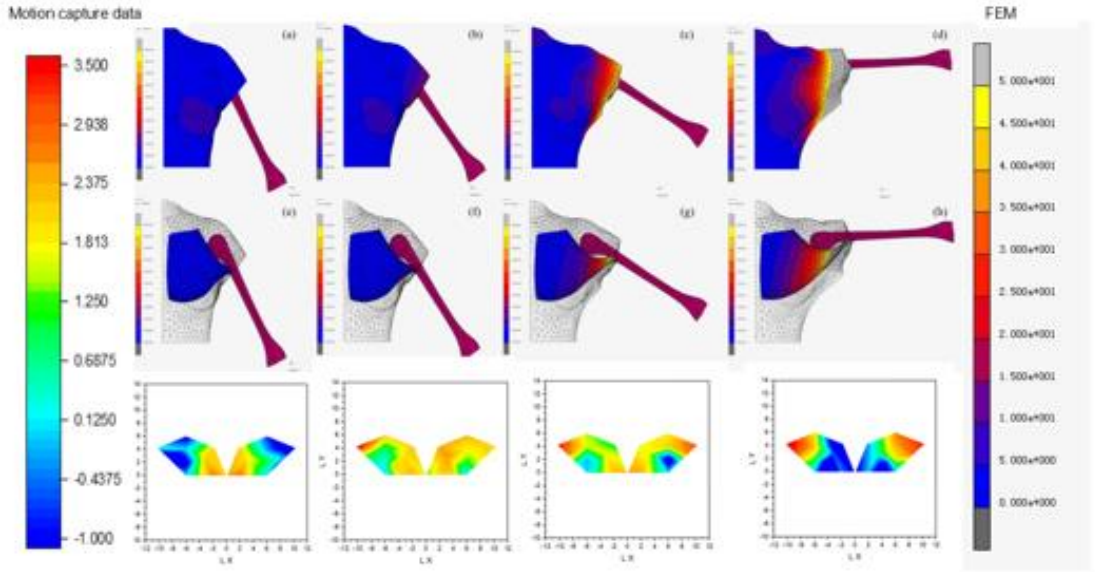
The total displacement of breast and displacement in x, y and z directions



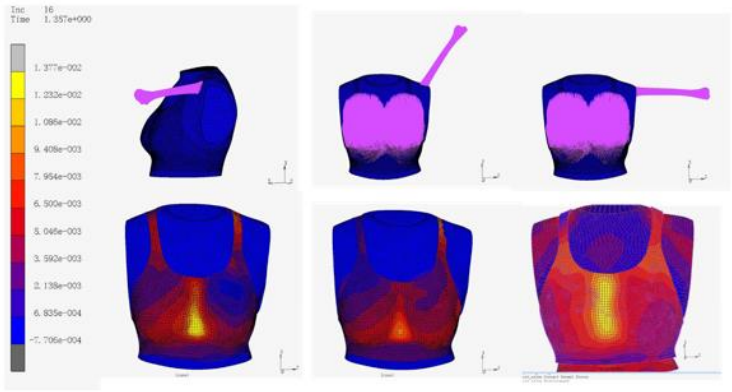
Research Methods & Materials

Milestone 3: Derive evidences on design features of brassiere from analysis and simulation

Task 2: Apply gravity on breast with the movement simulation of arm rotation and displacement based on experimental data. Deformation of breast is simulated with pressure and stress distribution.



The simulation of total displacement of the breast during the abduction from 30° to 90°

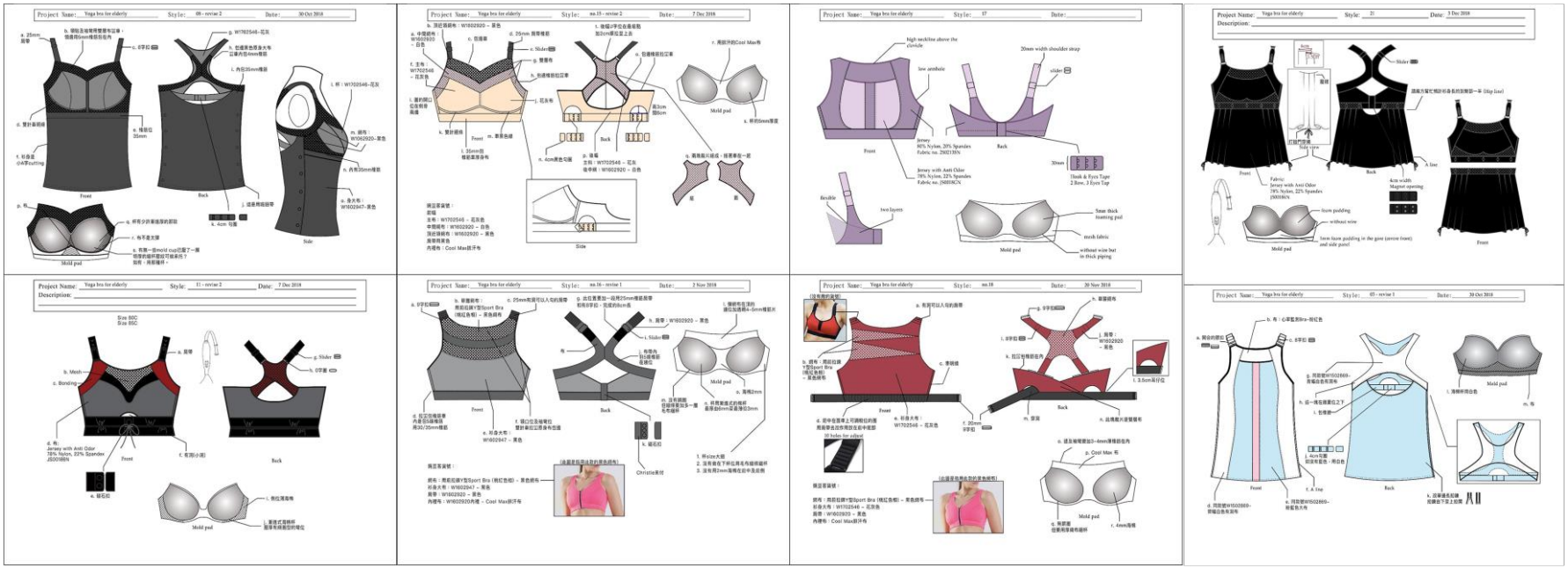


The simulation of total displacement of the breast and bra under different arm positions

Research Methods & Materials

Milestone 4: Findings are suggested to design features of a collection of senior brassiere styles

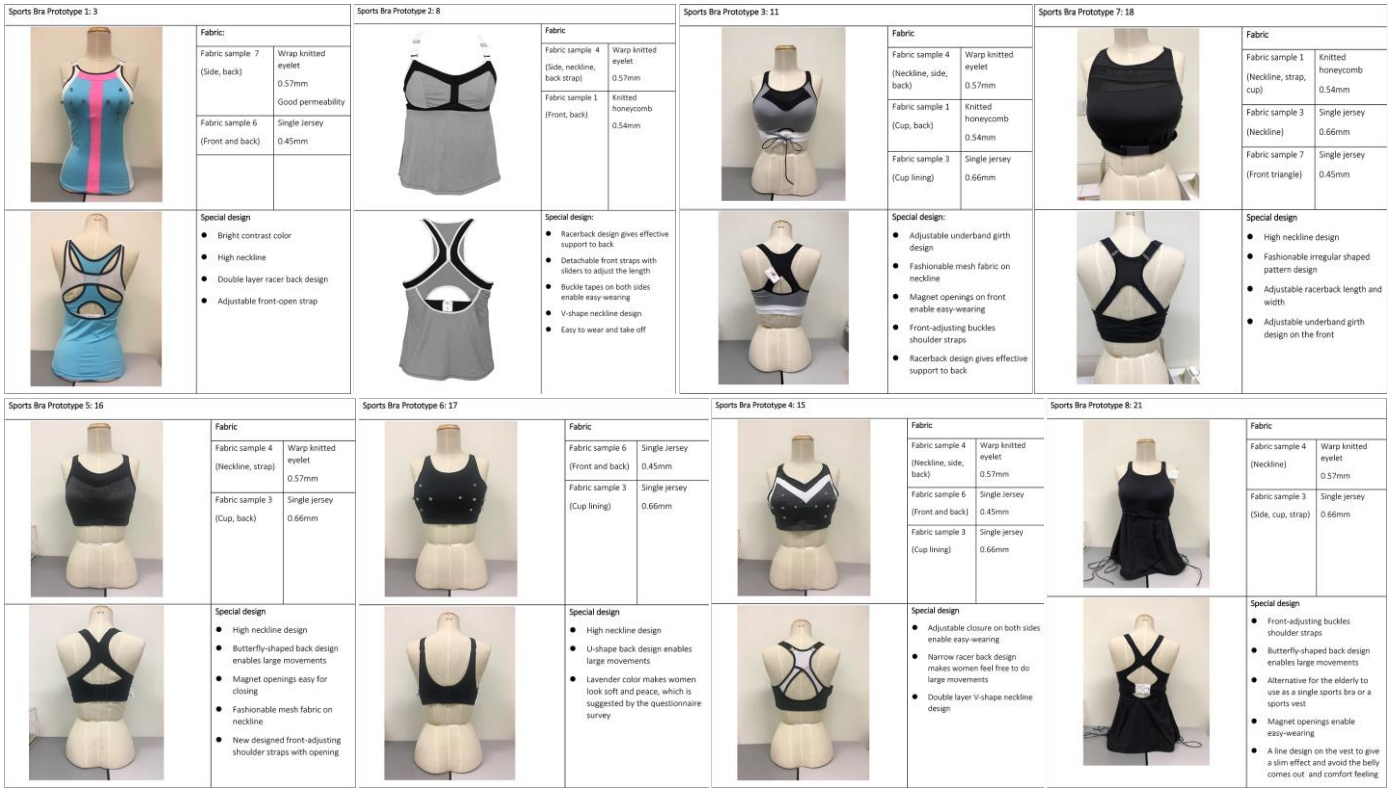
From the previous analysis, findings can be derived to suggest design features and framework for senior women clothing and sports wear. Design collection of 8 styles of aesthetic and functional brassieres for senior women, supported with evidence on design features, construction specification, wear trial and movement analysis.



Highlights of features: Racerback design gives effective support to back, Detachable front straps with sliders to adjust the length, New designed front-adjusting shoulder straps with opening, Narrow racer back design makes women feel free to do large movements, Magnet openings easy for closing, Buckle tapes on both sides enable easy-wearing, Adjustable front-open strap, Double layer racer back design, Adjustable racerback length and width, U-shape back design enables large movements, Butterfly-shaped back design enables large movements, Adjustable underband girth design on the front, Double layer V-shape neckline design

Research Methods & Materials

Milestone 4: Findings are suggested to design features of a collection of senior brassiere styles



Sports Bra Prototype 1: 3

Fabric:	
Fabric sample 7 (Side, back)	Wrap knitted eyelet 0.57mm Good permeability
Fabric sample 6 (Front and back)	Single Jersey 0.45mm

Special design
- Bright contrast color
- High neckline
- Double layer racer back design
- Adjustable front-open strap

Sports Bra Prototype 2: 8

Fabric	
Fabric sample 4 (Side, neckline, back strap)	Warp knitted eyelet 0.57mm
Fabric sample 1 (Front, back)	Knitted honeycomb 0.54mm

Special design:
- Racerback design gives effective support to back
- Detachable front straps with sliders to adjust the length
- Buckle tapes on both sides enable easy-wearing
- V-shape neckline design
- Easy to wear and take off

Sports Bra Prototype 3: 11

Fabric	
Fabric sample 4 (Neckline, side, back)	Warp knitted eyelet 0.57mm
Fabric sample 1 (Cup, back)	Knitted honeycomb 0.54mm
Fabric sample 3 (Cup lining)	Single jersey 0.66mm

Special design:
- Adjustable underband girth design
- Fashionable mesh fabric on neckline
- Magnet openings on front enable easy-wearing
- Front-adjusting buckles shoulder straps
- Racerback design gives effective support to back

Sports Bra Prototype 7: 18

Fabric	
Fabric sample 1 (Neckline, strap, cup)	Knitted honeycomb 0.54mm
Fabric sample 3 (Neckline)	Single jersey 0.66mm
Fabric sample 7 (Front triangle)	Single jersey 0.45mm

Special design
- High neckline design
- Fashionable irregular shaped pattern design
- Adjustable racerback length and width
- Adjustable underband girth design on the front

Sports Bra Prototype 5: 16

Fabric	
Fabric sample 4 (Neckline, strap)	Warp knitted eyelet 0.57mm
Fabric sample 3 (Cup, back)	Single jersey 0.66mm

Special design
- High neckline design
- Butterfly-shaped back design enables large movements
- Magnet openings easy for closing
- Fashionable mesh fabric on neckline
- New designed front-adjusting shoulder straps with opening

Sports Bra Prototype 6: 17

Fabric	
Fabric sample 6 (Front and back)	Single Jersey 0.45mm
Fabric sample 3 (Cup lining)	Single jersey 0.66mm

Special design
- High neckline design
- U-shape back design enables large movements
- Lavender color makes women look soft and peace, which is suggested by the questionnaire survey

Sports Bra Prototype 4: 15

Fabric	
Fabric sample 4 (Neckline, side, back)	Warp knitted eyelet 0.57mm
Fabric sample 6 (Front and back)	Single Jersey 0.45mm
Fabric sample 3 (Cup lining)	Single jersey 0.66mm

Special design
- Adjustable closure on both sides enable easy-wearing
- Narrow racer back design makes women feel free to do large movements
- Double layer V-shape neckline design

Sports Bra Prototype 8: 21

Fabric	
Fabric sample 4 (Neckline)	Warp knitted eyelet 0.57mm
Fabric sample 3 (Side, cup, strap)	Single jersey 0.66mm

Special design
- Front-adjusting buckles shoulder straps
- Butterfly-shaped back design enables large movements
- Alternative for the elderly to use as a single sports bra or a sports vest
- Magnet openings enable easy-wearing
- A line design on the vest to give a slim effect and avoid the belly comes out and comfort feeling

Design features highlights:

- A line design on the vest to give a slim effect and avoid the belly comes out and comfort feeling
- Alternative for the elderly to use as a single sports bra or a sports vest
- Bright contrast color
- Easy to wear and take off
- Fashionable irregular shaped pattern design
- Fashionable mesh fabric on neckline
- High neckline design
- Lavender color makes women look soft and peace

Research Conclusions

From the analysis of user personas, physical and psychological needs, sports exercise behaviour, brassieres design and comfort issues, and also with the reference from experiments, wear trial results, design criteria with features of construction were established. The idea of this was to ensure the brassiere that meet the design needs, has effective support, high stability and comfort in a way that is also easy to wear. The chosen textile material for the new design have all been objectively tested, and especially focused on features that is included in the design criteria, such as moisture management property, air permeability and extensibility.

Besides the cross disciplinary collaboration with the domain of textile and clothing, this design research project also adopted mechanical engineering approach in supporting the design features in relation to human body factors and comfort. The nonlinear finite element model of breast, torso, shoulder and upper arm was constructed to simulate the 3D distribution of pressure exerted by hyper-elastic materials to the breast skin. The skin extension data was collected from motion capture experiment in a three-dimensional space. The computation was conducted for calculating the skin extension and body movement. These calculations can infer the distribution of breast pressure when senior women are wearing different sports bra to do different posture and movements. The results can also show the relationship in supporting the breast, skin and features of brassieres design.

Dissemination and Distribution of Outcomes

- 4 international, double-blind peer-reviewed journals
- Among the journals, the highest Google Scholar h5-index is 50, with InCites JCR IF (SCIE) as 3.485.
- 7 international conference proceedings
- 3 design patents under State Intellectual Property Office of the People's Republic of China
- 1 local seminar, 1 seminar in China
- 2 exhibitions under the theme of elderly innovation
- Major academic research collaboration with the Apparel & Art Design College (Xian Polytechnic University) and College of Mechanical Engineering (Beijing University of Technology)
- The research has facilitated the collaboration with 3 universities, and 4 departments
- 1 major industry collaboration with Regina Miracle International (Holdings) Limited in the design patent
- 2 PhD research students support
- 2 funded ITF (Innovation and Technology Commission) research projects under ITSP (Innovation and Technology Support Programme)

Dissemination and Distribution of Outcomes

Journal Publications

Year	Research Publication
2017	**Current Trends in Biomedical Engineering & Biosciences** Lau, N. & Yu, W. (2017). Application of marker data sequences for analyzing nonlinear breast deformation. Current Trends in Biomedical Engineering & Biosciences, 8(5), 555750. DOI: 10.19080/CTBEB.2017.08.555750
2019	**Computer-Aided Design (Google Scholar h5-index: 38, InCites JCR (SCI): 3.049)** Sun, Y., Yick, K.L., Yu, W., Chen, L.H., Lau, N., Jiao, W.Z., & Zhang S.C. (2019). 3D bra and human interactive modeling using finite element method for bra design. Computer-Aided Design 114, 13-27. DOI: 10.1016/j.cad.2019.04.006
2019	**Journal of the Mechanical Behavior of Biomedical Materials (Google Scholar h5-index: 50, InCites JCR (SCIE): 3.485)** Sun, Y., Chen, L.H., Yick, K.L., Yu, W. Lau, N., & Jiao, W.Z. (2019) Optimization method for the determination of Mooney-Rivlin material coefficients of the human breasts in-vivo using static and dynamic finite element models. Journal of the Mechanical Behavior of Biomedical Materials 90, 615-625. DOI: 10.1016/j.jmbbm.2018.11.016
2019	**International Journal of Management and Applied Science** Zhang, J., Sun, Y., Lau, N., Yip, J., & Yu, W. (2019). FE Model for Biomechanical Analysis and Prediction of Older Women Breast Deformation. International Journal of Management and Applied Science. (in press)

Dissemination and Distribution of Outcomes

Journal: Current Trends in Biomedical Engineering & Biosciences

Abstract: Previous studies on 3D breast motion have limitations on providing ground truth and thorough accuracy on fine and subtle movement of breast movement during physical activities because of technical challenges in using markers to present breast movement. In this study, a total of 81 reflective markers were placed on the left breast to identify the 3D nonlinear movement and asymmetric deformation of the breast while treadmill running. The results revealed that the breast movement and deformation exhibit nonlinear and asymmetrical patterns over time. This research provides a breakthrough in overcoming the technical challenges of using massive number of markers and novel approach in breast motion study for the visualization of dynamic breast movement.

The Current Trends in Biomedical Engineering & Biosciences is an Open Access journal publishing Original research articles, Reviews, Mini reviews, Short communications, Opinions and Letter to editors. The Journal is enthusiastic in the development and dissemination of knowledge concerning Biomedical Engineering & Biosciences: seeks to close the gap between engineering and medicine, coalescethe design and problem solving skills of engineering with medical and biological sciences which helps in development of sophisticated instruments which are used for the advance health care treatment, including diagnosis, monitoring, and therapy.

Link to the journal

Link to the publication entry

Dissemination and Distribution of Outcomes

Journal: Computer-Aided Design

Abstract: Bra design experiences a long process of development including some key aspects like material selection, pattern making and grading. It is anticipated that a 3D bra design that incorporates information on the interaction between bra and breast can effectively improve the design process for optimal fit and comfort. In this paper, a novel personalized modeling system based on finite element (FE) contact model is first presented to simulate the breast-shaping effect and the pressure distribution of the skin exerted by a bra. The new knowledge can provide a basis for the computer-aided-design of well-fitting bras for the target customers.

Computer-Aided Design is a leading international journal that provides academia and industry with key papers on research and developments in the application of computers to design. Computer-Aided Design invites papers reporting new research, as well as novel or particularly significant applications, within a wide range of topics, spanning all stages of design process from concept creation to manufacture and beyond.

Journal Impact Factor from InCites Journal Citation Reports (JCR)
Impact Factor 2018: 3.049
5-year Impact Factor: 3.471

CiteScore 2018: 4.14

SCImago Journal Rank (SJR) 2018: 1.302
Scource Normalized Impact per Paper (SNIP) 2018: 2.202

Google h5-index: 38
Google h5-median: 52

Link to the journal

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Dissemination and Distribution of Outcomes

Journal: Journal of the Mechanical Behavior of Biomedical Materials

Abstract: It has been a long-standing problem in the engineering design of bra for optimal support and shaping due to the difficulty of quantifying the hyper-elastic properties of human breasts. This study is to determine and verify a new set breast material coefficients by finite element analysis obtaining the non-linear properties of breast soft tissues and the corresponding deformations during motions. The method proposed provides an effective way to determine the breast properties for predicting breast deformation and analysis of the bra-breast contact mechanism and thus, improving the design of bras.

The Journal of the Mechanical Behavior of Biomedical Materials is concerned for the benefit of an interdisciplinary readership. Reports of fundamental scientific investigations, experimental and theoretical works are welcome, as are articles concerned with the practical application of materials in medical devices. The journal publishes with the mechanical deformation, damage and failure under applied forces, of biological material (at the tissue, cellular and molecular levels) and of biomaterials.

Journal Impact Factor from InCites Journal Citation Reports (JCR)
Impact Factor 2018: 3.485
5-year Impact Factor: 3.643

CiteScore 2018: 3.82

SCImago Journal Rank (SJR) 2018: 1.037
Scource Normalized Impact per Paper (SNIP) 2018: 1.480

Google h5-index: 50
Google h5-median: 73

Link to the journal

Link to the publication entry

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Conference Publications

Year	Research Publication
2017	**Asia Textile Conference** Zhang. S.C., Yu, W., & Lau, N. (2017). Design criteria for age-friendly bras. In Proceedings of 14th Asia Textile Conference, 170-173.
2017	**Asia Textile Conference** Sun, Y., Yu, W., Lau, N., Chen, L.H., Jiao, W.Z. (2017). Analysis of beast deformation in different leaning angles using finite element method. In Proceedings of 14th Asia Textile Conference, 98-101.
2018	**Textile Institute World Conference** Zhang, S., Yick, K. L., Yu, W. & Lau, N. (2018). Analysis of bra design features for older women. The 91st Textile Institute World Conference.
2018	**Textile Institute World Conference** Sun, Y., Yick, K. L., Yu, W., Chen, L., Lau, N. & Jiao, W. (2018). FE simulation of the interaction between breast and daily bra during wearing. The 91st Textile Institute World Conference.
2019	**International Conference on Science, Engineering & Technology** Zhang, J., Sun, Y., Lau, N., Yip, J., Yu, W. (2019). FE Model for Biomechanical Analysis and Prediction of Older Women Breast Deformation. In Proceedings of International Conference on Science, Engineering & Technology. Osaka, Japan.
2019	**International Association of Societies of Design Research Conference** Zhang, J., Lau, N., Yip, J., Yu, W. (2019). Assessing User Needs to Explore Determinants of Sports Bra for Elderly Women during Yoga Exercises. International Association of Societies of Design Research Conference. Manchester, UK.

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Patents

Year	Research Publication
2017	Utility Model Patent & Invention Patent. Easy-wearing bra with a crossed front closure. No. 201711034293.5. P.R. China: State Intellectual Property Office of the People's Republic of China; SIPO.
2018	Utility Model Patent. Easy-wearing convertible yoga bra for elderly. No. 201821053487.X. P.R. China: State Intellectual Property Office of the People's Republic of China; SIPO.
2019	Utility Model Patent. Packable sleeved sports bra with tunnel back storage. No. 201920119654.4. P.R. China: State Intellectual Property Office of the People's Republic of China; SIPO.

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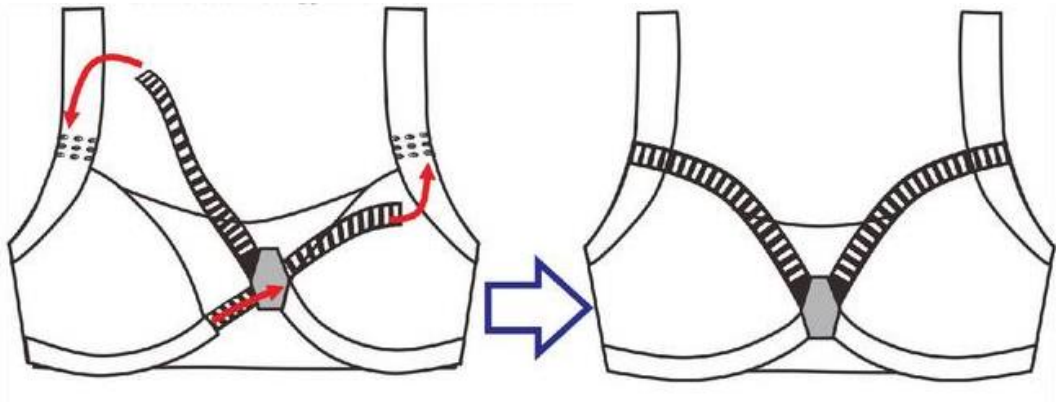
Patent: Easy-wearing bra with a crossed front closure

Utility Model Patent. Easy-wearing convertible yoga bra for elderly. No. 201821053487.X. P.R. China: State Intellectual Property Office of the People's Republic of China; SIPO.

The present technology to achieve front closure for bra is to use a hard buckle (mostly metal or plastic) to replace gore. Instead of handle in the back, users can wear the bra by closing in the front. The problems are [1] the underband length is usually not adjustable; [2] the buckle applies too much pressure on the chest when the user bows her body; [3] some buckles are too thick and obvious as seen from outer clothes; [4] metal components might cause allergy when contact the skin directly, while plastic buckles have short life span and easily broken when handled improperly.

The merits of this patent is the application of two crossing straps that can hold bras in proper place as bottom elastics. The formation of a diamond shape loop acting as gore to fix the two straps, and the application of closure buttons on the shoulder straps. These design features solve the above mentioned problems for the aim of user comfort.



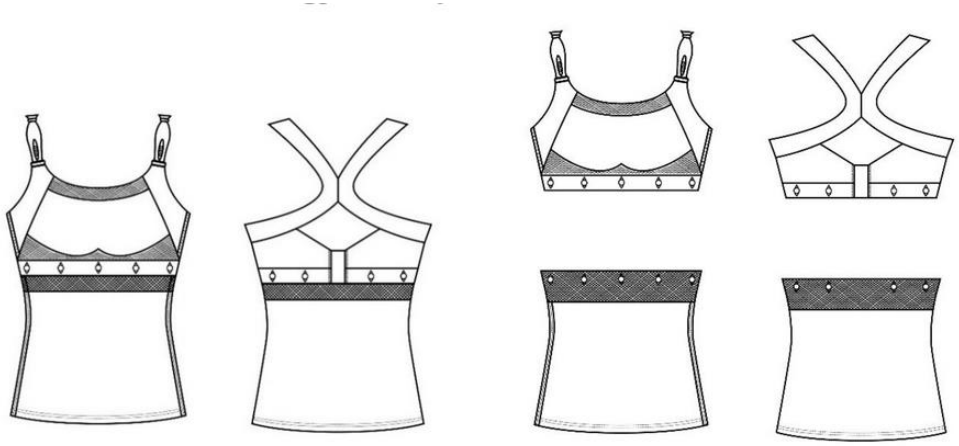
Dissemination and Distribution of Outcomes

Patent: Easy-wearing convertible yoga bra for elderly

Utility Model Patent & Invention Patent. Easy-wearing bra with a crossed front closure. No. 201711034293.5. P.R. China: State Intellectual Property Office of the People's Republic of China; SIPO.

Elderly changes in the body form with aging, and have limited dexterity that makes them unable to raise their arms very far. The connective tissues supporting the breasts become less elastic. The spine begins to curve and shoulders become rounded. However, most of the yoga bras in the market do not consider much about these issues for elderly. The design problems for elderly include: [1] hook and eye at the back are difficult to handle; [2] compression bra is not adjustable for underband and strap length; [3] body form exposed may cause embarrassment; [4] straight back provides limited back support and crossover movement; [5] conventional sports bra cup does not have enough support for static and stretching exercises.

The merit of this patent contains two major parts of the bra with the top and bottom pieces, together with a number of design features tailored for the characteristic of elderly. The top portion is a yoga bra with two front adjusting straps, the bottom portion is a convertible body. Both have fastening means for ease of putting on and taking off. The detachable bottom portion solves the embarrassing situation of body exposed. Elderly users can attach or detach the bottom portion according to their needs, such as different yoga movements and personal preferences. The special strap design allows easy and adjustable strap length at the front. Magnetic closure provided extra convenience to wear. The design of hollow butterfly back provided additional back support for rounded shoulders and curved spine. The double layered side panel is moisture wicking and breathable. The molded cup is embedded in the yoga bra, with density and thickness designed for elderly comfort and support.



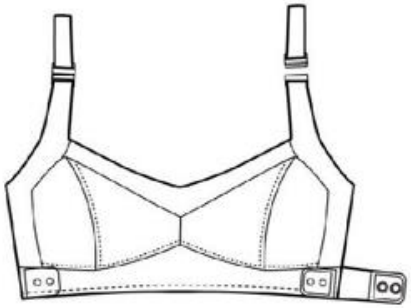
Dissemination and Distribution of Outcomes

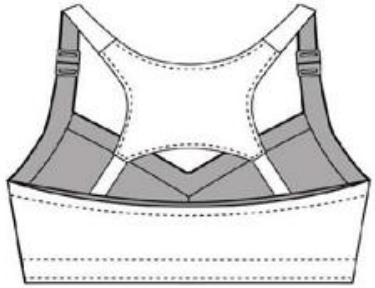
Patent: Packable sleeved sports bra with tunnel back storage

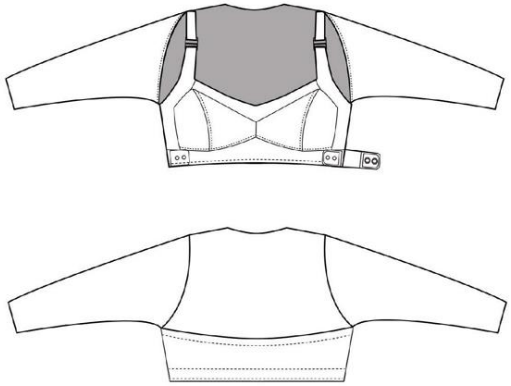
Utility Model Patent. Packable sleeved sports bra with tunnel back storage. No. 201920119654.4. P.R. China: State Intellectual Property Office of the People's Republic of China; SIPO.

Compression sports bra is a common type for elderly to wear while performing outdoor or indoor activities. Some design issues users face include: [1] discomfort caused by the compression force acting on the breast; [2] distortion to the shape of breast; [3] compression bra is usually not adjustable for underband and strap length; [4] shoulder strap is usually not detachable at front for easy-wearing; [5] wide skin area of exposure to sunlight and wind, even mosquitoes bite while outdoor; [6] body form exposed may cause embarrassment.

The merit of this patent is the application of packable sleeves construction to achieve the functions and convenient to wear, while protecting the body with comfort. The sports bra contains two major parts: the sports bra with tunnel back storage, and the packable sleeves on back. The tunnel back storage is formed by two ply fabric construction with fastening tape. The wearer can take it out or store the sleeves according to their needs and preferences, for instance, during outdoor exercises, or static stretching during cool-down routine after exercise. There is one set of opening buckles on the shoulder straps, one set of magnetic buckles on the underband. These buckles make it easier for elderly to adjust the length of underband and strap to better fit the body shape, especially on the pressure imposed on the skin, fat and muscles underneath.







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Seminars

Year	Research Publication
2017	Find a suitable bra to wear. Research Seminar Series. Institute of Active Ageing. 24 Mar 2017.
2018	Sports bra for elderly – research and design. Silk Road Fashion Technology Academic Forum. Xian Polytechnic University. 5 Jun 2018.

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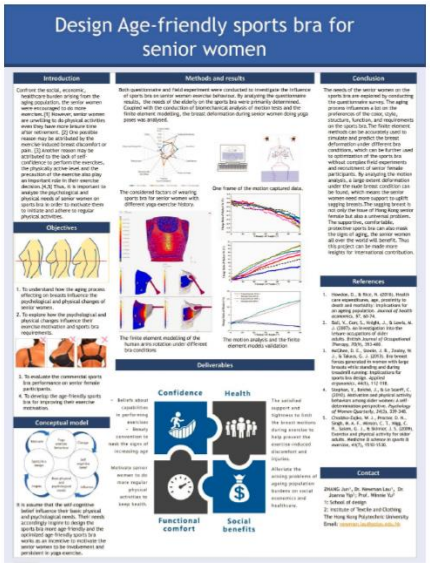
Exhibitions

Year	Research Publication
2018	Age-friendly Bra Series with Biomechanical Design. Golden Age Expo cum Summit. Golden Age Foundation. Hall 1C, HK Convention and Exhibition Center. 26-28 Jan, 2018.
2018	Aesthetic and Functional Design of Yoga Bra for Elderly. Gerontech Innovation Expo Cum Summit. HKSAR Government and Hong Kong Council of Social Service. Hall 1A-1B, HK Convention and Exhibition Center. 22-25 Nov, 2018.



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